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The gender gap in engineering education: a case study from Central Queensland University

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ABSTRACT: The achievements of a nation are largely based on advances in science and technology, as well as rising levels of educational achievements of the population. In addition, resources devoted to educating the female population therefore yield significant benefits for individuals, households, the economy and the nation as a whole. It is well established that in Australia, the proportion of female graduates in mathematics, science and engineering is much lower than in many other OECD countries. The focus in this article is on engineering education with particular reference to data from Central Queensland University (CQU), Rockhampton, Australia, for the 1989-2002 period. Even though female and male engineering graduates in Australia have a virtual guarantee of employment, the low level of female enrolment in engineering education continues to be anomalous and unsatisfactory. This ongoing phenomenon is the outcome of numerous factors, including the self-defeating belief that technical education is primarily a male domain. After canvassing the likely reasons for the gender gap in engineering education, a series of recommendations to increase the enrolment levels of female students in engineering are also included in this article.

INTRODUCTION

The achievements of a nation are primarily based on the advancement of science, technology and raising the levels of educational achievement of the population generally, thereby yielding total factor productivity gains [1][2]. The common wisdom that women play vital roles in the education of their households is well supported by a wealth of research. A nation cannot neglect the human resource capital of females who comprise about 50% of the population. Investment in educating the female population yields significant benefits for the individual, the household, the economy and the nation as a whole.

Society is not indifferent as to whether a person is a male or female, so that *there are everywhere two actual norms for human life* [3]. It is recognised that parents at home and teachers at school play an important role in directing the minds of young females in making choices regarding subjects. Gender-role specialisation commences from a young age, with girls being given dolls and kitchen utensils, while boys play with cars and Mechano sets [4][5]. The failure of a household to promote the education and skill acquisition of its females amounts to an externality in human capital formation. This type of household or family failure is allocationally inefficient, diminishes the capability and well-being of females and, in turn, the collective welfare and output of the total household [6].

The education system, therefore, has an important role to play in countering historically-based norms, values, and the gender-based division of labour and household failure. Young females need to be encouraged, motivated and provided with additional support, if necessary, from primary to high school level to study subjects like physics, chemistry and mathematics (PCM), which will allow them the option of taking up, for example, engineering as a degree programme at the tertiary level.

In this article, the authors deal with the gender gap in engineering education in general and compares female/male graduate outcomes at Central Queensland University (CQU), Rockhampton, Australia, in particular. Also the reasons for the low enrolment of women in engineering education and the recommendations for increasing female student enrolment in engineering education are well explained in this article.

THE GENDER GAP IN ENGINEERING EDUCATION

Gender-based trends and patterns in enrolment at the primary, secondary and tertiary level are quite similar. Females generally tend to be concentrated in certain areas of study like arts, education, humanities, home economics, business and other science related areas like nursing, rather than in science, engineering and technology (SET) programmes. In conditions of sustained economic growth and equal opportunity in the labour market, women can now participate in higher education, as well as the workforce, on a more or less equal basis. The gender gap in education is costly to economic development, household and individual welfare as measured by Gross Domestic Product (GDP) per capita. In these circumstances, Australian state and federal governments, in conjunction with the universities and professional bodies, need to encourage investment by female students in engineering programmes in order to address the gender-gap in engineering education and the shortage of graduates entering the profession.

Women and engineering are two terms that are not traditionally linked with one another. In today's information age, it is critical to harness the technical skills and talents of both men and women in order to ensure the competitive position of the Australian economy in the global economy. Science, engineering and technology provide creative and well-paid jobs for both men and women.

There have been a number of recent studies at the national and international levels that have addressed various issues relating to women in engineering education. Also, as a result of various well-funded individual initiatives and programmes, including *Women in Science and Technology* (WISE) in the UK and *Women in Science Engineering and Technology* (SET) in Australia and similar type of programmes in New Zealand, Canada and the USA, the participation of women in engineering in these countries has tended to increase over recent years.

However, women still represent only a fraction of practicing engineers in Australia, New Zealand, the UK, USA and Canada. Furthermore, in Australia, the total course commencements by students in engineering was projected to decline over the period 1995-2001 [7]. Females represent 51% of the total Australian population. However, according to the advisory group *Women in Science Engineering and Technology*, females represent approximately:

- 12.5% of all engineering students;
- 6.5% of science and engineering academics;
- 29% in natural sciences outside of the higher education sector;
- 2.9% of building or engineering professionals [8].

In comparison, in the para-professional fields, women account for 43% of medical and science technical officers and technicians [9]. Research by the Engineering Training Authority revealed that the female component of graduates in engineering and technology has risen from 5% in 1979 to 14% in 1993. While an improvement, female participation in these areas lags far behind their male counterparts [10].

The Turves Green School in Birmingham, England, UK, provides a good example of the impact an individual programme can have in redressing the gender gap in engineering education. Turves Green obtained a TES Engineering Council Neighbourhood Engineering School of the Year Award for encouraging girls to enter the engineering profession. Almost 80 of the 700 pupils at the Girls School attended the after-school Engineers Club, which was supported by local employers and the automobile manufacturer Rover [11]. Club members research, design and undertake a project that generally has practical applications. The School curriculum extends to include activities of the Engineers Club and supports teamwork. Students are also encouraged to obtain awards and accreditation.

In many western countries the undergraduate female participation in engineering now ranges from 10-20%. In Australia, initiatives to encourage women in engineering started in the late 1980s to the early 1990s. More than one-half of the country's engineering faculties had programmes to encourage female participation in engineering education [12]. However, at that time, females represented only 13% of students commencing Bachelor of Engineering courses [13]. They also represented a substantially lower percentage of practising engineers [14].

What accounts for this gender gap and the under-representation of women in engineering education and the profession?

Engineering education involves 4-5 years of tertiary study to attain a Bachelor level degree, while starting salaries are higher for engineering degree graduates compared to, for example, business degree graduates. Research has indicated that female students are far less likely than their male counterparts to have taken advanced level PCM courses in high school and hence are less prepared to enter engineering programmes at the tertiary level. Secondly, females hold different values regarding family and work as a result of gender role identity; thus, they are less likely to choose *male-oriented* occupations or study such areas like engineering.

CQU ENGINEERING GRADUATES (1989-2002) CASE STUDY: DEGREE GRADUATES

During the period 1989-2002, the CQU underwent substantial development, accompanied by four changes in nomenclature: from a College of Advanced Education in 1989 to the University College of Central Queensland in 1990, then University of Central Queensland, and finally, Central Queensland University (CQU). In 1998, the six faculties of CQU merged into five faculties. As part of this development, the James Goldstone Faculty of Engineering (JGFE) became the Faculty of Engineering and Physical Systems. Data about engineering graduates during the period 1989 to 2002 was collected from the Information Technology section of the CQU and analysed to compare female-male engineering graduate output.

The total number of male-female engineering degree (BE) graduates from 1989-2002 is shown in Figure 1. The total number represents graduates from all discipline areas of engineering, ie civil, mechanical and electrical.

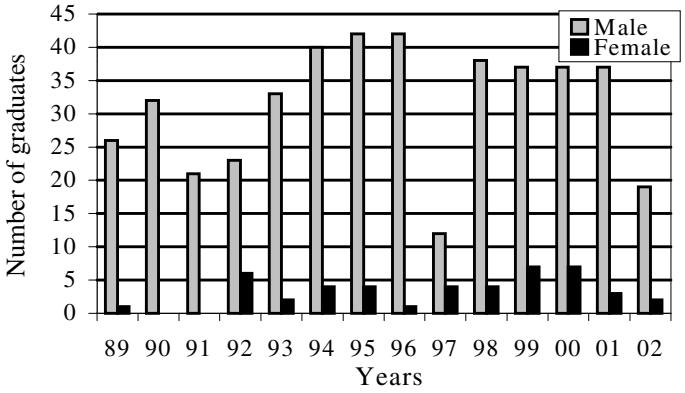

Figure 1: Engineering degree graduates (1989-2002).

In brief, female engineering graduates are conspicuous by their absence. There was only one female graduate in 1989, then a gap until 1992. In 1992, the total number of graduates was 29, the year in which this institution became a full university. There was a marked rise of student enrolments in 1992 and 1993, and these students graduated in 1995 and 1996, representing an increase of 58% in 1995 and 62% in 1996, respectively, compared with 1992. However, there was no noticeable improvement in the number of female graduates over this period. In fact, from an initial low base, they declined further.

In 1995, the JGFE introduced the Co-op Engineering programme. This is a sandwich programme in which students undertake an industrial work placement for six months in their second and fourth year of study. Although until 2002, total graduates numbers maintained its trend, this was not accompanied by a correlative increase in female graduates.

DIPLOMA AND TECHNOLOGY GRADUATES

The data given in Figure 2 includes diploma/technology graduates from all engineering disciplines, ie civil, mechanical and electrical. In 1989, two female students graduated in these courses from this institution, representing only 4.7% of the total diploma/technology graduates. The change in status from College of Advanced Education to that of a University has not improved the rate of enrolment by diploma/technology students. There was only an 11% increase in diploma/ technology graduates, compared with a 58% increase in engineering degree graduates.

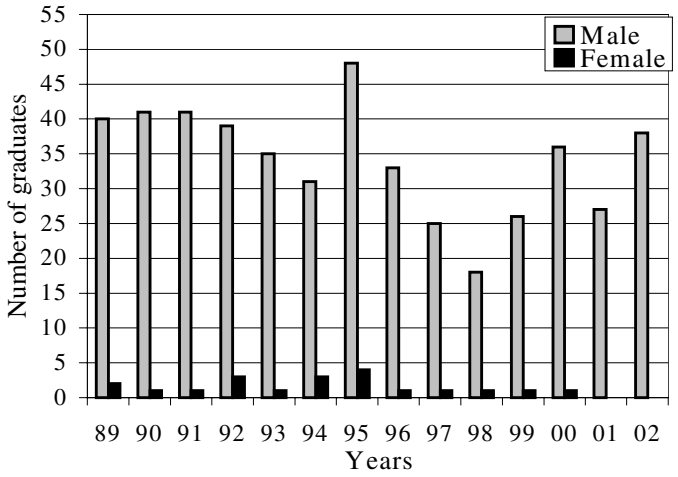

Figure 2: Diploma and technology graduates in engineering (1989-2002).

REASONS FOR LOW ENROLMENT IN ENGINEERING

A growing body of studies show the ways in which gender socialisation in the family, school, institution and society shape and influence attitude, behaviour and the choices of occupation [4][15][16]. The causes of a low participation rate of women in engineering include inadequate training in schools in PCM, which are a prerequisite for an engineering course, and adverse gender role socialisation.

Encouragement, preparation and identification of student talents and interests should take place at an early stage, since students without any background in PCM are disadvantaged and not qualified for an engineering education. As females, on average, take less advanced PCM subjects than males, increased participation by females in these high school PCM subjects is foundational to addressing the gender gap in engineering education at the tertiary level.

Gender role socialisation theory is derived from neoclassical economic theory [17]. It provides insight into career choices based upon this type of gender role socialisation, where individuals weigh the various career choices available to them and make a rational decision based upon a calculation of the associated costs and benefits. Also, males and females perceive and anticipate different roles played by them at home and work. Males tend to choose male-oriented courses and occupations as the main income earner of the household. Females, on the other hand, tend to choose courses in female-oriented areas of arts, education and health, with caring and nurturing roles.

A policy implication for institutions is that if women are to be attracted to engineering programmes, engineering needs to be seen as a *female friendly* field of education and occupation. Parents, teachers, tertiary institutions, industry groups and government policy makers must modify their attitudes in the light of gender role socialisation research.

Gender role socialisation, household attitudes and values all combine to diminish the likelihood that females will choose engineering as a course of education and a career. If females were provided with a positive image of the work involved and sufficient information, then they would be more likely to choose engineering as a course in terms of the intrinsic rewards of being an engineer. Engineering can be a very rewarding profession – both intrinsically and extrinsically [18][19]. However, these two types of rewards need to be more clearly articulated to high school students if the immediate problem of a gender-gap in engineering education is to be addressed.

RECOMMENDATIONS

Motivating, recruiting and retaining females in engineering are major challenges. Status, financial support and scholarships are very important incentives. Government and industry support is also required. Studies show that governments spend only a fraction of the amount necessary to address the gender gap in engineering. The following recommendations are made:

- There is a lack of basic information about engineering in society. The younger generation seems to believe that an engineer is someone who works on trams and roads [20]. Para-professional courses attract a high salary and societal respect compared with engineering. In Asian countries, by comparison, engineering is a highly regarded professional course. Engineering graduates can add *Er* in front of their name, just as doctors use the abbreviation *Dr* as their title.
- It is necessary to change the prevailing attitude of society that engineering is a man's world. Today, an engineering occupation can be just as interesting and creative as any other professional employment, requiring analytical, high level technological and computing skills, etc [21].
- The profession can be promoted by utilising good marketing videos for school visits to show the different areas of engineering, the life of an engineering student, engineers at the workplace and how engineers are contributing to technological advancement [22].
- Engineering curricula should be gender inclusive, providing hands-on training, with easy access to campus facilities and gender balance in academic and laboratory staff. On campus placements for employment at the end of their academic courses provide opportunities for students to undertake part-time work while studying [23].
- Administration of an active network/register for women in engineering in order to share common interests and discuss mutual problems in a male dominated profession through workshops, discussion groups, seminars and newsletters.
- Encouragement of mature age female students (TAFE, tradespersons), who have a distinct advantage over younger students in terms of skills and experience, to undertake engineering studies.
- Refresher courses for high school teachers in PCM content and methodology, as well as collaboration for curriculum development.
- Development of an active strategy to mentor female students and monitor their exit from engineering courses through interviews, surveys and counselling.

CONCLUSIONS

With the growth of various industrial sectors over recent decades, engineering has achieved greater visibility in the occupational hierarchy. With globalisation, privatisation and increasing competition in the global economy, engineers have an increasingly important role in developing the technologies of the future, besides helping to restructure and maintain the competitiveness of Australia's economy as a whole.

Given the ongoing shortage of engineering graduates, women must be drawn upon in large numbers to a profession that is made more attractive to them in reliance on various financial and family-friendly measures, such as maternity leave and childcare.

Engineering has the distinction of being the most male dominated of all the professions. Although the participation rate of females in engineering education has increased since 1980, the gender-gap in engineering graduates still exists, despite an increasing demand for engineering graduates and the inevitable growth of the engineering profession in the future.

Female enrolment in engineering programmes across Australia has become static. By comparison, the number of females entering non-traditional professions, like law, media and accounting, has increased. It is clearly evident that young females still do not perceive engineering as an alternative successful career option despite the high intrinsic and extrinsic rewards it offers. Young females are still not attracted to a profession that has a male-dominated image, is mathematical and technical, and places little emphasis on social and interpersonal communication skills.

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